DOCUMENT RESUME

ED 265 169 TM 850 632

AUTHOR McDaniel, Ernest; And Others
TITLE Measuring Spatial Ability with a Computer Managed Task.
PUB DATE Aug 85
NOTE 10p.; Paper presented at the Annual Meeting of the American Psychological Association (Los Angeles, CA, August 23-27, 1985).
PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Cognitive Measurement; Cognitive Tests; *Computer Assisted Testing; *Flight Training; Postsecondary Education; Predictive Validity; *Simulation; *Spatial Ability; *Test Validity; Visualization; Visual Measures; Visual Perception
IDENTIFIERS Rod and Frame Test; Shephard Metzler Rotations Test; *Wheatley Cube

ABSTRACT

This study presents data augmenting the validity studies of the Wheatley Cube (McDaniel and Kroll, 1984), a computer managed test of spatial visualization. Twenty-one students in pilot training are administered several instruments designed to measure the ability to construct a cognitive three-dimensional space, including: (1) the Wheatley Cube, (2) aircraft orientation task, (3) Shepard-Metzler Rotations Tests, and (4) Rod and Frame Test. Findings of this study suggest a moderately high relationship between performance on the Wheatley Cube and the Shepard-Metzler. Both tests perform equally well in predicting the ability of student pilots to quickly determine the orientation and direction of their aircraft in simulated flight. The Wheatley Cube does a remarkably better job of predicting performance on a cognitive task than does the Shepard-Metzler, suggesting that the Wheatley Cube may be measuring a somewhat different component of visualization than the Shepard-Metzler. (MO)

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MEASURING SPATIAL ABILITY WITH A COMPUTER MANAGED TASK

Ernest McDaniel
Mark Kroll
Michael Nolan

Purdue University

A paper presented at the annual meeting of the
American Psychological Association
Los Angeles, August, 1985

TM 850632

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Abstract

This study presents data augmenting the validity studies of the Wheatley Cube (McDaniel & Kroll, 1984), a computer managed test of spatial visualization. The Wheatley Cube, the Shepard-Metzler, an aircraft orientation task and a reasoning test in which solutions are facilitated by visualizing spatial arrays were administered to 21 students in pilot training. The two spatial tests correlated with each other and with the aircraft orientation task. The Wheatley Cube test, however, correlated much higher than the Shepard-Metzler with performance on the cognitive task facilitated by visualizing arrays.

MEASURING SPATIAL ABILITY

WITH A COMPUTER MANAGED TASK

McDaniel and Kroll (1984) offer evidence that the Wheatley Cube, a computer managed task requiring the subject to locate an unseen dot within an enclosed space, may measure an individual's ability to construct a mental representation of a three dimensional space and to maintain orientation in such a space. In this study, the Wheatley Cube is employed, along with other instruments, in a further investigation of the Wheatley Cube as a measure of the ability to construct a cognitive three-dimensional space.

Procedure

The subjects were 21 students in a pilot training program enrolled in a ground trainer course simulating actual flight. As described below, the flight simulator was used to obtain a measurement of the subjects' ability to determine the heading and position of the aircraft, thus providing an important variable for the study. In addition to the aircraft orientation task, subjects were administered the Shepard-Metzler Rotations Test, the Rod and Frame Test and a three-terms test accompanied by retrospective reports. Each of these instruments is described more fully below.

Instruments

The Wheatley Cube. Figure 1 is an illustration of the Wheatley Cube (Wheatley, 1982), a computer managed task in which the subject attempts to locate an invisible dot which is inside the cube.

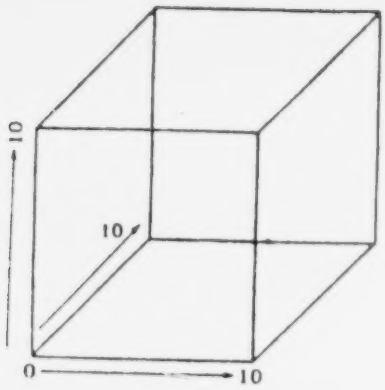

Figure 1. Wheatley Cube Schematic

Subjects view the Wheatley Cube on a computer screen and enter their estimate of the location by specifying values for each of the three axes. The computer provides feedback by telling the subject how many spaces their probe has missed the dot. The direction of the error is not specified in the feedback. This process continues until the subject has found the dot or exhausted 18 trials.

Using a TRS-80 Color Computer, subjects were administered three presentations of the cube, each presentation providing 18 trials to locate the dot. The score was the trial number on which the dot was located. Performance on the Wheatley Cube was indicated by the average score for the three presentations.

Aircraft Orientation. The aircraft orientation task required the subject to locate his aircraft based on readings from the automatic

direction finder (ADF). The instructor outside the simulator set the cockpit instruments for a specified magnetic heading and displayed sequentially the relative bearings for each of two radio stations. The subject inside the simulator indicated as quickly as possible the position and heading of his aircraft from the instrument readings. Responses were recorded on pre-printed grid paper. The score for each trial was the distance in millimeters of the actual position from the position recorded by the subjects. Five trials were administered and performance on the aircraft orientation task was indicated by the average score for the five trials.

Shepard-Metzler Rotations Test. The Shepard-Metzler Rotations Test (Shepard & Metzler, 1971) is a widely used test of the ability to visualize the total gestalt of a visual stimulus and to rotate the image or perform complex comparisons with the image. Twenty items of this test were administered. For each item, the subject selects two of four drawings that represent a given object rotated in space.

Rod and Frame Test. The Rod and Frame Test stems from classic work first reported by Witkin and Asch (1948). Using a portable version of the rod and frame test subjects were administered 8 trials to adjust the upright to a vertical position when the surrounding frame was tilted to the left or right. Each trial was scored as the number of degrees the rod deviated from the vertical when the subject judged it as upright. Performance on the rod and frame test was the average deviation for the eight trials.

Three-Terms Test. The Three-Terms Test consisted of 24 items of the form, "Circle is lighter than Square. Triangle is darker than Square. Is Triangle lighter than Circle?" The items were selected from Egan and Grimes-Farrow's (1982) problems designed to encourage the use of spatial representational schemes or visual comparative strategies. Each problem was presented orally by a tape recorder and subjects had 5 seconds in which to mark a "Yes" or "no" or "?" on an answer sheet.

One week after the experiment, subjects were mailed a form asking them to check which of two written descriptions more closely characterized their own way of solving the three terms problems. Fifteen retrospective reports were returned and these were used to classify subjects according to strategies employed, i.e., as abstract directional thinkers or concrete properties thinkers.

Results and Discussion

A correlation matrix was generated among all variables.

Insert Table 1 about here

Examination of the matrix revealed that the two tests of spatial ability employed in this study, the Shepard-Metzler and the Wheatley Cube correlated significantly with each other ($r=.37$ p $.05$). Both the Shepard-Metzler and the Wheatley Cube are significantly correlated with performance on the Aircraft Orientation task. Finally, it may be noted that there is a substantial difference between the correlations of the Shepard-Metzler and the Three-Terms Test ($r=.12$) and the Wheatley Cube and the Three-Terms Test ($r=.52$).

The exploratory variable, the Rod and Frame Test, did not correlate significantly with any of the other variables in the study. The correlations ranged from a low of .05 with the Shepard-Metzler to a high of .26 with the aircraft orientation task.

The findings of this study suggest a moderately high relationship between performance on the Wheatley Cube, a new procedure for measuring spatial ability, and the Shepard-Metzler, a firmly established measure. Both tests perform equally well in predicting the ability of student pilots to quickly determine the orientation and direction of their aircraft in a simulated flight.

The Wheatley Cube does a remarkedly better job of predicting performance on a cognitive task (Three-Terms Test) than does the Shepard-Metzler. Egan and Grimes-Farrow (1982) report that subjects who solve three-terms tasks by constructing spatial arrays do somewhat better than subjects who solve three-terms tasks by visualizing concrete properties of the objects in the three terms task. This observation suggests that the Wheatley Cube may be measuring a somewhat different component of visualization than the Shepard-Metzler.

Table 1

Correlations among two spatial ability tests and measures of Aircraft Orientation, Three-Term Strategies, and Three-Terms Scores

Spatial Ability Tests	Aircraft Orientation (n-21)	Three-Terms Strategies (n-15)	Three-Terms Scores (n-21)
Shepard-Metzler	.39*	.42	.12
Wheatley Cube	.37*	.44*	.52**

*Sig. < .05

**Sig. < .01

References

Egan, D. E., & Grimes-Farrow, D. D. (1982). Differences in mental representations spontaneously adopted for reasoning. Memory & Cognition, 10, 297-307.

McDaniel, E. & Kroll, M. (1984). The Wheatley Cube as a performance measure of visualization. Paper presented at the annual meeting of the American Educational Research Association, New Orleans.

Shepard, R. N., & Metzler, J. (1971). Mental rotation of three-dimensional objects. Science, 171, 701-703.

Wheatley, G. (1982). The Wheatley Cube. West Lafayette, IN: Educational Programs, Inc.

Witkin, H. A., & Asch, S. E. (1948). Studies in Space Orientation. IV. Further experiments on perception of the upright with displayed visual fields. Journal of Experimental Psychology, 38, 762-782.